

# Real Convergence in the European Union

**Francisco José Veiga\***

Universidade do Minho - Portugal

## **Abstract:**

This essay deals with real convergence in the European Union (EU). Real convergence is here defined as convergence of GDP per capita in Purchasing Power Standard. I examine whether there is empirical evidence of real convergence among EU countries or regions and if the current effort towards nominal convergence has slowed real convergence. The main findings are that there has been some real convergence at the country level, mainly before the mid-1970s, but not much evidence of real convergence is found at the regional level. I also find that the convergence criteria set in the Treaty of Maastricht may have slowed real convergence in the European Union.

*Keywords:* Real convergence, European Union, countries and regions

*JEL classification:* C23, F43, O47, O52

---

\*Francisco José Veiga

Escola de Economia e Gestão

Universidade do Minho

P-4710 Braga – Portugal

Tel. #: +(351) 53-604534

Fax #: +(351) 53-676375

Email: [fjveiga@eeg.uminho.pt](mailto:fjveiga@eeg.uminho.pt)

The author wishes to thank John McDermott, McKinley Blackburn, Janice Breuer, and George Krause for very helpful comments. Financial support received from *Programa PRAXIS XXI* - Portugal.

## **1 INTRODUCTION**

This essay deals with real convergence among the member countries of the European Union (EU). Real convergence is here defined as convergence of Gross Domestic Product per capita (GDPpc) in Purchasing Power Standard (PPS). I measure it four ways. Real convergence occurs if (1) poorer countries or regions are growing faster than rich ones; (2) if the dispersion of GDPpc is decreasing over time; (3) if country or regional rankings of GDPpc are not persistent; or (4) if the regional distribution of GDPpc is evolving towards an increased concentration at the center (at the EU average).

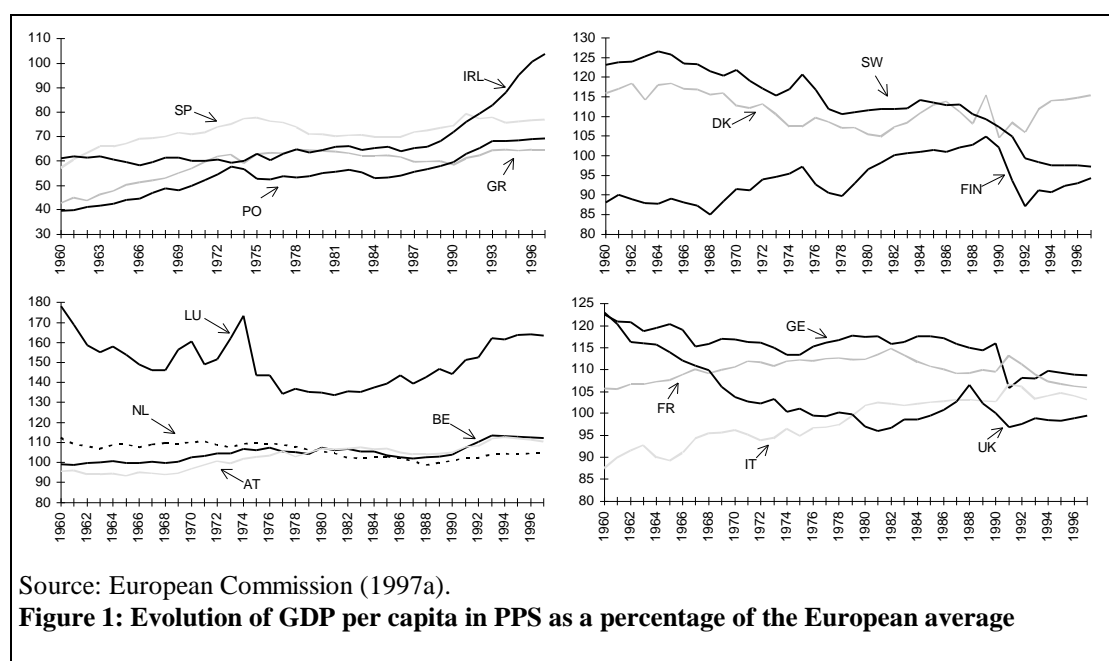
Using these measures, I investigate whether there is evidence of real convergence among EU countries or regions and if the current efforts towards nominal convergence slowed real convergence in the EU. As some of the poorer countries in the EU were also the ones farther away from fulfilling the convergence criteria set in the Maastricht Treaty, it is possible that the restraints they imposed on monetary and fiscal policy have slowed growth in these countries and thus interfered with real convergence in the EU as a whole.

The main findings are that there is some evidence of real convergence at the country level, mainly before the mid-1970s, but not much evidence of real convergence is found at the regional level. I also find that the criteria set in the Treaty of Maastricht may have slowed real convergence in the European Union at the country and regional levels.

## **2 EVOLUTION OF GDPpc IN PPS AS A PERCENTAGE OF THE EUROPEAN AVERAGE**

Figure 1 shows the evolution of GDPpc in PPS, as a percentage of the EU average, from 1960 to 1997. It gives a rough idea of convergence of GDP per capita (real convergence) across the 15 EU members, and makes it easy to identify the richest and poorest countries. Although Luxembourg has always been the richest country and Portugal and Greece

the two poorest, some convergence has occurred. First, all the countries that had GDP per capita below the EU average in 1960 are now above it or much closer. The most spectacular recoveries were those of Ireland and Portugal, with increases of 42.7 and 29.8 percentage points, respectively.<sup>1</sup> Second, Sweden and the UK, the second and third richest in 1960, are slightly below the EU average in 1997, with decreases of 25.9 and 23.5 percentage points, respectively. Finally, Germany, the second richest during the 1980s, had a considerable drop in GDP per capita after its reunification.



<sup>1</sup> For an analysis of recent economic performances, see: European Commission (1996b) for Ireland, and European Commission (1997b) for Portugal. For a study on Portugal-EU convergence, see: Barros and Garoupa (1996).

### 3 GROWTH OF GDP PER CAPITA ( $\beta$ CONVERGENCE)

#### 3.1 *Convergence among countries*

Absolute convergence of GDP per capita occurs if poor countries grow faster than rich ones. The most common way to check for convergence of GDPpc among a group of countries is to estimate a regression of growth of GDPpc over a certain period on the initial level of GDPpc. Baumol (1986), De Long (1988), Barro (1991), and many others, estimated convergence equations over cross-sections of countries.<sup>2</sup> Most studies find results consistent with those of Barro (1991), who finds evidence of convergence of GDPpc for OECD countries but not for the entire world, for which there is some evidence of divergence. Barro and Sala-i-Martin (1995) and Sala-i-Martin (1996a,b) find evidence of convergence for European regions, U.S. states, Canadian provinces, and Japanese prefectures.

One problem with cross-sectional studies is that estimated convergence rates may be affected by cyclical fluctuations of GDPpc, in the sense that the choice of the starting and ending dates for the periods under analysis may influence results. Another problem is that they only take cross-sectional variation into account, ignoring the dynamic (time) variation. Those problems can be somewhat mitigated by estimating a panel regression. A panel regression takes both dimensions into account (cross-section and time), and thus its estimates may be less affected by cyclical fluctuations of GDPpc. Furthermore, cross-sectional estimations of convergence with just 15 countries would have very low power. However, I also handle the cyclical influence on convergence by testing for convergence using the trend component of GDPpc, estimated using the Hodrick-Prescott decomposition method. Results obtained when

---

<sup>2</sup> Studies focusing on GDPpc convergence ( $\beta$  convergence) include, among others: Barro (1991), Barro and Sala-i-Martin (1991, 1995), Baumol (1986), Ben David (1993,1996), Caselli, Esquivel, and Lefort (1996), De Long (1988), Islam (1995), Mankiw, Romer, and Weil (1992), and Sala-i-Martin (1996a,b).

using the trend component of GDPpc are not exactly equal to those obtained when using GDPpc itself, but conclusions regarding real convergence in Europe do not change.<sup>3</sup>

In my tests for absolute convergence, I follow Ben-David (1993, 1996), using a convergence equation that is a Dickey-Fuller test on the log of GDPpc relative to the mean of the group under consideration. The only difference is that my equation includes a constant. Table 1 reports the results of a regression of annual growth of GDPpc in PPS, as a percentage of the EU average, on lagged GDPpc (also in PPS and as a percentage of the EU average) and a constant, for a panel of the 15 EU countries from 1960 to 1997. Since the equation adopted here is that of a Dickey-Fuller unit root test, statistical significance is evaluated using Dickey-Fuller critical values instead of those of the T-Student distribution.<sup>4</sup>

When no country effects are assumed, European countries' GDP per capita converged at an average rate of roughly 2.3% a year, that is, the average disparity was cut by 2.3% a year. The half-life, the number of years required for the average disparity to be cut in half, is approximately 30 years. Thus, there is some evidence of absolute convergence of GDPpc for EU countries. Then, the sample was split into sub-periods using the following break points: 1973, first oil shock and the UK, Denmark, and Ireland join the European Community (EC); and 1986, Single European Act and Portugal and Spain join the EC. The third sub-period (1986-97) was divided into before and after Maastricht (1986-91 and 1992-97, respectively). For two of the sub-periods, some evidence of absolute convergence remains. Chow tests, not reported here, always reject the hypothesis of equal coefficients in all sub-periods.

---

<sup>3</sup> Results obtained when using the trend component of GDPpc are not shown here. See Veiga (1998).

<sup>4</sup> A time trend and lags of the dependent variable were not statistically significant when included in the regressions (results not shown here).

**Table 1: Convergence of GDPpc for EU countries**

| Time Period | No country effects |           | Random Effects |           |
|-------------|--------------------|-----------|----------------|-----------|
|             | b                  | Half-Life | b              | Half-Life |
| 1960-97     | -.0229***          | 29.9      | -.0245***      | 27.9      |
| 1960-72     | -.0331***          | 19.5      | -.0340***      | 20.0      |
| 1973-85     | -.0074             | 93.3      | -.0125         | 55.1      |
| 1986-97     | -.0225*            | 31.2      | -.0245         | 27.9      |
| 1986-91     | -.0296             | 23.1      | -.0297         | 23.0      |
| 1992-97     | -.0142             | 48.5      | -.0336         | 20.3      |

Source: Author's calculations using European Commission (1997a).

Notes: - The following equation was estimated by OLS:

$$\ln(y_{i,t} / y_{i,t-1}) = a + b \ln(y_{i,t-1}) + e_{it}$$

where  $y_{i,t}$  stands for relative GDPpc of country  $i$  at time  $t$ , and  $e_{it}$  is a white noise error term. A country-specific error term is added when assuming random effects;

- The number of stars indicates the significance level at which the relevant null hypothesis is rejected: “\*\*\*” for 1%, “\*\*” for 5%, and “\*” for 10% (Dickey-Fuller critical values were used);
- The half-life is equal to:  $\ln(.50) / \ln(1+b)$ .

One problem with the panel analysis above is that there may be country effects in the error term. Statistically, these individual country effects may be treated as fixed or random. If they are treated as fixed, the identification of  $\beta$  will rely solely on variation in incomes within countries, and no information from cross-country differences in average growth rates and incomes will be used. The problem with that approach when testing for convergence is that it implies that countries may be converging to different points. This is what Barro and Sala-i-Martin (1991, 1995) and Sala-i-Martin (1996a,b) call “conditional  $\beta$  convergence”. It shows how fast countries or regions are converging to their own steady states.<sup>5</sup>

<sup>5</sup> One simple way to test for conditional convergence would be to include country dummy variables in the estimations of Table 1 (controlling for fixed effects).

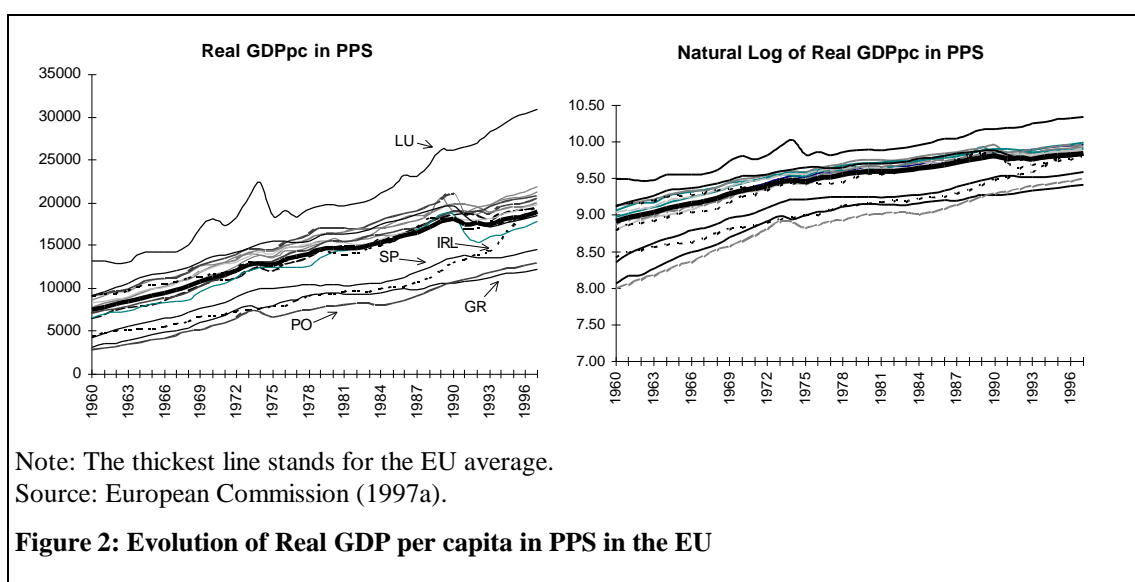
But, if steady states differ according to differences in technologies, education, or other characteristics, countries or regions may be converging to different levels of GDPpc. Income gaps among them may never be eliminated even in the presence of a rate of conditional convergence of 2% per year that Barro and Sala-i-Martin (1995) and Sala-i-Martin (1996a,b) find for different groupings of regions and different time periods. Furthermore, according to Quah (1996a,b,c,d and 1997) and Galor (1996), conditional convergence may not avoid persistence, stratification, and the formation of convergence clubs, with countries concentrating into groups of rich and poor. Since my primary concern is to find out if poor countries are catching up with richer ones, conditional convergence is irrelevant, and so I will not treat country effects as fixed.

The alternative is to view country effects as random. Instead of estimating a set of given (unknown) constants for each of the countries, a single intercept is estimated; country effects merely serve to make the error covariance matrix non-diagonal. This model assumes that country specific constant terms are randomly distributed across cross-sectional units, and uncorrelated with the other regressors. The error covariance matrix will now reflect the fact that the error term for each country may be correlated over time. Ignoring the presence of random effects can lead to biased statistical inference in OLS regressions. Unlike in the fixed effects model, cross-country variations in the variables are used in estimating  $\beta$ . As country effects are not directly estimated, it is implicitly assumed that countries are not converging to different steady states. Thus, assuming country effects to be random rather than fixed seems to be appropriate when testing for absolute convergence.

Results of convergence estimations when accounting for random effects are shown in the right panel of Table 1. Results are very similar to those of the left panel, except for 1986-97, for which the null hypothesis of a unit root is no longer rejected. In general, estimated coefficients get slightly higher in absolute value and half-lives slightly lower. The annual rate

of convergence for 1960-97 is now 2.45% and the half-life is around 28 years. Since the only sub-period for which there is evidence of convergence is 1960-72, it seems that most of the real convergence found for 1960-97 happened before 1973.

Table 1 shows evidence of convergence of GDPpc relative to the EU average for the entire time period considered (1960-97). Thus, countries' GDPpc seem to be converging towards the average. But, this is not enough to know whether each country is approaching a steady state or not. For that, one needs to analyze the behavior of the EU average. That is done in Figure 2, which shows the evolution of real GDPpc in PPS (and its natural log) for the EU average (the thick line) and for all member countries. Although most of the countries concentrate around the average (especially for log of GDPpc), there are some outliers: Luxembourg, which does not seem to be converging, and Spain, Greece, and Portugal, which are converging slowly. Ireland is an interesting case, since it had a GDPpc below that of Spain until 1990, and is now slightly above the EU average.





Except in the beginning of the 1990s, the EU average GDPpc followed a pattern of continued growth, with an average annual rate of growth of approximately 3% for the entire period. The level reached in 1997 is almost three times higher than that of 1960. The same can be said about most countries. Thus, EU countries seem to be converging to an ever-increasing average instead of approaching a steady state.

### 3.2 *Convergence among regions*

Although results above show some evidence in favor of convergence among EU countries, the same may not necessarily happen at the regional level. That is, we still do not know if there is regional convergence at the EU level, or at the country level. Table 2 shows the results of panel estimations of convergence equations (assuming random effects) for 77 NUTS I regions and 206 NUTS II regions from 1977 to 1995 and several sub-periods.<sup>6</sup>

As done above, annual growth of GDPpc in PPS as a percentage of the EU average is regressed on lagged GDPpc (also as a percentage of the EU average) and a constant. Data on regions of the former East Germany are not available before 1991, and these regions benefited from an unusual amount of aid from the former West Germany that may justify their fast convergence. Since this may drive the results for the whole EU in favor of convergence at the regional level, I also report the results obtained when the regions of the former East Germany are excluded from the sample (“No East GE”). Finally, I report the results of convergence equations for countries, so that convergence across countries and regions can be compared.

---

<sup>6</sup> “NUTS” is a classification scheme for European regions into statistical territorial units. The 15 EU member countries are divided, for statistical purposes, into 77 NUTS I regions or, even further, into 206 NUTS II regions. They can also be divided into NUTS III regions, but since data on GDPpc before the late 1980s is not available for many of these regions, NUTS III regions were not considered in this paper. Eurostat's Regio database provides data on GDPpc in PPS for the EU as a whole, for countries, and for regions (NUTS I, NUTS II, and NUTS III). GDPpc in PPS as a percentage of the EU average is obtained by dividing the GDPpc of the country or region in question by that of the EU as a whole, and multiplying that ratio by 100.

**Table 2: Convergence of GDPpc for EU regions and countries**

|            | 1977-95   |                  | 1977-85   |                  | 1986-95   |                  | 1986-91   |                  | 1992-95   |                  |
|------------|-----------|------------------|-----------|------------------|-----------|------------------|-----------|------------------|-----------|------------------|
|            | <b>b</b>  | <b>Half Life</b> | <b>b</b>  | <b>Half Life</b> | <b>b</b>  | <b>Half Life</b> | <b>b</b>  | <b>Half Life</b> | <b>b</b>  | <b>Half Life</b> |
| NUTS I     | -.068***  | 9.8              | -.0088    | 78.4             | -.0905*** | 7.3              | -.0297*** | 23.0             | -.1283*** | 5.0              |
| No East GE | -.0146*** | 47.1             | -.0088    | 78.4             | -.0231*** | 29.7             | -.0297*** | 23.0             | -.0128*   | 53.8             |
| NUTS II    | -.0438*** | 15.4             | -.0176*** | 39.0             | -.0576*** | 11.6             | -.0374*** | 18.1             | -.0638*** | 10.5             |
| No East GE | -.0218*** | 31.4             | -.0176*** | 39.0             | -.0288*** | 23.7             | -.0374*** | 18.1             | -.0155*** | 44.3             |
| COUNTRIES  | -.0139    | 49.2             | -.0104    | 65.6             | -.0252    | 27.1             | -.0297    | 23.0             | -.0276    | 24.7             |

Source: Author's calculations using Eurostat (1998), *REGIO Regional Database*.

Notes: - Results were obtained estimating the following equation:

$$\ln(y_{i,t}/y_{i,t-1}) = a + b \ln(y_{i,t-1}) + u_i + e_{it}$$

where  $y_{i,t}$  stands for the GDP of region  $i$  relative to the EU average at time  $t$ ,  $u_i$  is a country specific error term, and  $e_{it}$  is the general error term;

- The half-life is equal to  $\ln(.50) / \ln(1+b)$ ;
- The number of stars indicates the significance level at which the relevant null hypothesis is rejected: “\*\*\*” for 1%, “\*\*” for 5%, and “\*” for 10% (for DF critical values);
- “No East GE” means that the regions of the former East Germany were excluded from the sample.

There is evidence of convergence of GDPpc among EU regions for the period 1977-95. Estimated coefficients are always statistically significant, and have a negative sign (as expected) in all four estimations. When all regions are included, panel estimations show annual convergence rates of roughly 7% for NUTS I regions and 4% for NUTS II regions, with half-lives around 10 and 15 years, respectively. This means that at the highest level of disaggregation (NUTS II) it would take around 15 years to cut the average disparity in half. When the five regions of the former East Germany are excluded, convergence is much slower and half-lives jump to around 47 years for NUTS I regions and 31 years for NUTS II regions. The two sub-periods show very different results. In the first (1977-85), estimated coefficients are not statistically significant at the NUTS I level and they are smaller in absolute value than for the entire period at the NUTS II level. Consequently, half-lives are longer. The opposite

happens in the second period (1986-95), which shows faster convergence and shorter half-lives than for the entire period.

Results for the period after Maastricht (1992-95) are also very sensitive to the inclusion of East German regions. When they are included, convergence is faster after Maastricht than before for NUTS I and NUTS II regions. When these regions are excluded from the sample (“No East GE”), convergence is slower after 1992 than before. Thus, it seems that, except for East German regions, the real convergence of European regions slowed after the Maastricht Treaty (half-lives are around 20 years for 1986-91 and above 40 years for 1992-95).

No evidence for convergence among countries is found for any of the periods considered. This is consistent with the results presented in Table 1 in which no evidence of convergence was found for the periods starting after 1972. Failure to reject the null hypothesis may also be due to the fact that the number of observations is much smaller for countries than for regions. The implied half-lives are close to those of the NUTS I regions when the regions of the former East Germany are excluded.

The previous table shows that there has been some convergence of GDPpc among regions of the EU. But, it is also important to find out whether regions within each country have converged with each other. Table 3 shows the results of panel estimates of convergence equations (assuming random effects) for NUTS I and NUTS II regions within each country from 1977 to 1995. As in the previous regressions, annual GDPpc growth was regressed on lagged GDPpc and a constant (with GDPpc in PPS now expressed as a percentage of the country average). The number of regions per country is indicated in the second column, and when data is not available since 1977 the starting date is indicated in parentheses. Half-lives are reported only for those cases in which the estimated coefficient on lagged GDPpc is

statistically significant and has a negative sign (the cases in which there is evidence of convergence).

**Table 3: Convergence within regions of the same country**

|                 |        | 1977-95  |           | 1977-85 |           | 1986-95  |           |
|-----------------|--------|----------|-----------|---------|-----------|----------|-----------|
|                 | # Reg. | b        | Half-Life | b       | Half-Life | b        | Half-Life |
| <b>NUTS I:</b>  |        |          |           |         |           |          |           |
| BE              | 3      | .0008    |           | .014    |           | -.0089   |           |
| GE (1978)       | 16     | -.139*** | 4.6       | -.0174  |           | -.148*** | 4.3       |
| West GE         | 11     | -.035    |           | -.0174  |           | -.083    |           |
| GR              | 4      | -.101**  | 6.5       | -.148** | 4.3       | -.022    |           |
| ES (1980)       | 7      | -.037    |           | -.0045  |           | -.015    |           |
| FR              | 9      | -.012    |           | .0084   |           | -.0124*  | 55.6      |
| IT              | 11     | -.0087   |           | -.0162  |           | -.0069   |           |
| NE              | 4      | -.058    |           | .033    |           | -.489*** | 1.0       |
| UK              | 11     | -.0151   |           | -.014   |           | -.014    |           |
| <b>NUTS II:</b> |        |          |           |         |           |          |           |
| BE              | 11     | -.0083   |           | .0031   |           | -.017    |           |
| GE (1978)       | 36     | -.120*** | 5.4       | -.030   |           | -.136*** | 4.7       |
| West GE         | 31     | -.036*   | 18.9      | -.030   |           | -.081*** | 8.2       |
| GR              | 13     | -.074*** | 9.0       | -.077   |           | -.055    |           |
| ES (1980)       | 18     | -.050**  | 13.5      | -.041   |           | -.048*   | 14.1      |
| FR              | 26     | -.0206** | 33.3      | -.013   |           | -.0175*  | 39.3      |
| IT              | 20     | -.029*   | 23.6      | -.038   |           | .0031    |           |
| NE              | 12     | -.053**  | 12.7      | .023    |           | -.403*** | 1.3       |
| AU (1988)       | 9      | -.0077   |           |         |           | -.0077   |           |
| PO (1980)       | 7      | -.154*   | 4.1       | -.063   |           | -.163    |           |
| FIN (1988)      | 6      | -.0212   |           |         |           | -.0212   |           |
| SW (1985)       | 8      | -.0193   |           |         |           | -.0193   |           |
| UK              | 35     | -.0198   | 34.7      | -.0099  |           | -.0052   |           |

Source: Author's calculations using Eurostat (1998), *REGIO Regional Database*.

Notes: - The following equation was estimated for each country (assuming random effects):

$$\ln(y_{i,t} / y_{i,t-1}) = a + b \ln(y_{i,t-1}) + u_i + e_{it}$$

where  $y_{i,t}$  stands for the GDP of region  $i$  relative to the country average at time  $t$ ,  $u_i$  is the region-specific error term, and  $e_{it}$  is the general error term;

- The number of stars indicates the significance level at which the relevant null hypothesis is rejected: “\*\*\*” for 1%, “\*\*” for 5%, and “\*” for 10% (for Dickey-Fuller critical values);
- The half-life is equal to:  $\ln(.50) / \ln(1+b)$ ;
- When data is not available since 1977, the starting date is indicated in parenthesis;
- “West GE” stands for Germany without the regions of the East.

Convergence equations were also computed for the former West Germany (“West GE”). As Denmark, Ireland, and Luxembourg are not divided into regions, convergence equations could not be estimated for these countries, nor for Sweden at the NUTS I level.

Reduced number of regions and lack of data for earlier years would also lead to a very small number of observations for Austria, Finland, and Portugal at the NUTS I level.

Table 3 shows evidence of convergence at the NUTS I level for only two countries, Germany and Greece. At the NUTS II level, some evidence of convergence is found for 7 out of 12 countries, but for two of these the estimated coefficient on lagged GDPpc is only marginally significant. Furthermore, there is weaker evidence of convergence in Germany when the regions of the East are excluded. As in the previous tables, convergence seems to be higher and half-lives shorter after 1986 than before. In short, there is not much evidence of convergence of GDPpc among regions of the same country.

#### **4 DISPERSION OF GDP PER CAPITA ( $\sigma$ CONVERGENCE)**

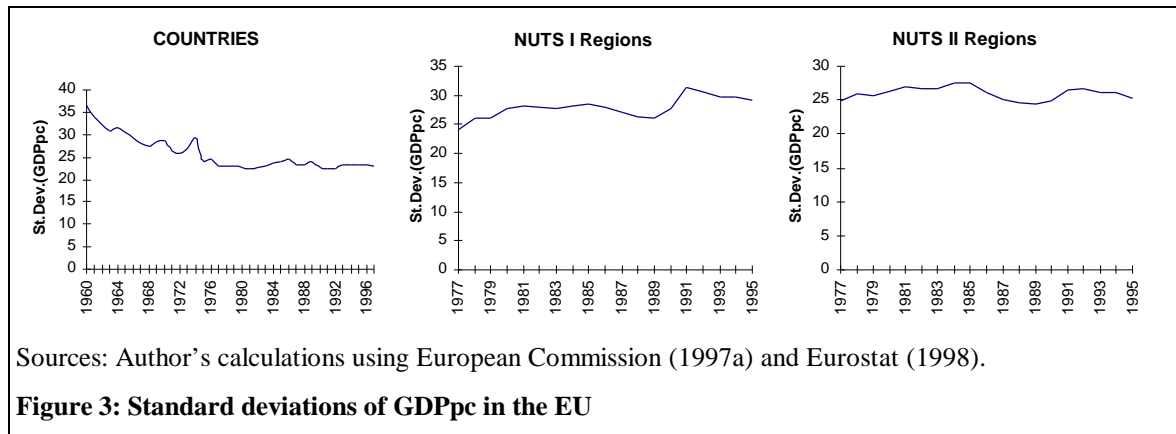
While  $\beta$  convergence deals with the speed at which poorer countries or regions catch up with rich ones,  $\sigma$  convergence<sup>7</sup> deals with the dispersion of GDP per capita across them. Evidence of convergence is found when the dispersion of real GDP per capita falls over time. Figure 3 shows the evolution of the standard deviations of GDPpc relative to the EU average for EU countries and regions. At the country level, this indicator of divergence shows a declining pattern from 1960 to 1997, which supports the hypothesis of  $\sigma$  convergence among EU countries.

That decreasing pattern of divergence is not found at the regional level, except after 1991. Standard deviations are relatively stable from 1977 to 1990. Then, there is an increase around 1990 because of the inclusion of the regions of the former German Democratic Republic, followed by a steady decrease, as those regions converge with the rest of Germany and with the EU. This may seem strange, as some evidence of convergence at the regional

---

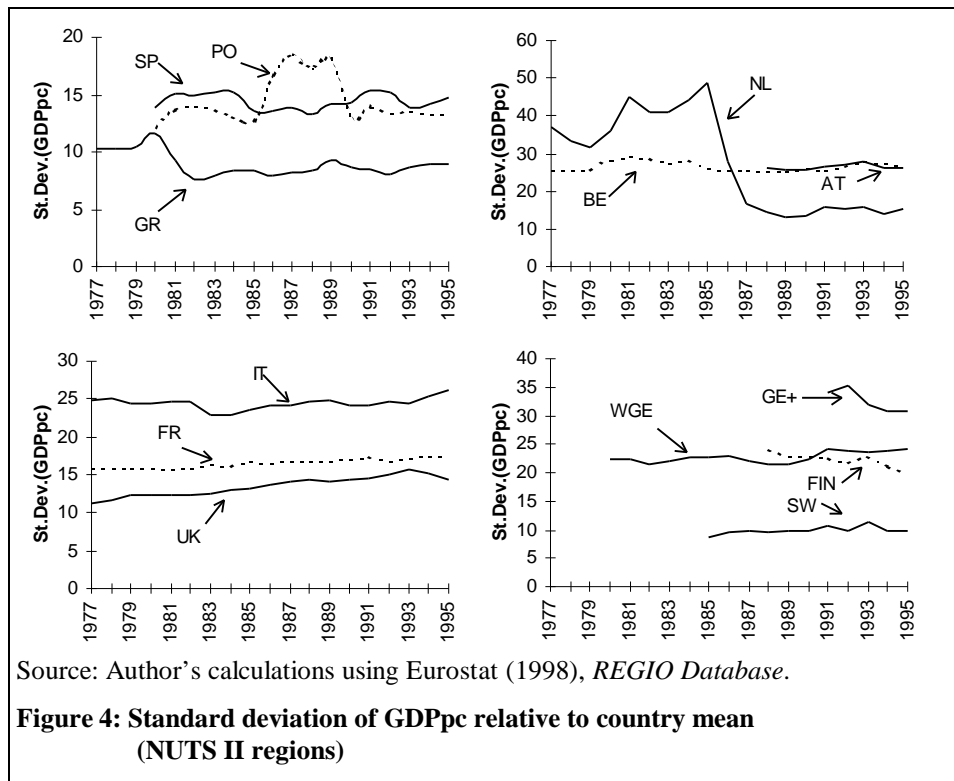
<sup>7</sup> See: Barro and Sala-i-Martin (1991, 1995), and Sala-i-Martin (1996a,b).

level was found in most of the estimations of the last section. It does not necessarily mean that the results are wrong because, as Sala-i-Martin (1996a,b) explains,  $\beta$  convergence is a necessary but not a sufficient condition for  $\sigma$  convergence.



Part of the contrasting evidence regarding convergence at the country and regional levels may be explained by the shorter time period available for the latter. Standard deviations at the country level seem to be declining at a faster pace before the mid-1970s than afterwards (which is consistent with the results of Table 1 and Table 2 and with those of Ben-David (1993)). In fact, the standard deviation of GDPpc relative to the EU average, is relatively stable in the last 20 years (1977-97), which is consistent with the findings at the regional level.

Different results for countries and regions may also be found when regions within countries are not converging with each other. That is, if countries are converging but regions within each country are growing apart, dispersion measures may be decreasing at the country level but not at the regional level. Figure 4 shows the evolution of standard deviation of GDP per capita as a percentage of the country mean for 12 EU countries (those that have regions at the NUTS II level).



The Netherlands, and reunited Germany (GE+)<sup>8</sup>, are the only cases in which there is clear evidence of  $\sigma$  convergence among regions. Some convergence seems to have taken place in Greece, but only until 1982. For Austria, Belgium, France, Finland, West Germany (WGE), Italy, Sweden, and the United Kingdom, standard deviations are relatively stable over time, ending with levels close to those at which they started (although slightly higher in most of them). Spain and Portugal are more unstable but they also end up almost at the level of 1980.

<sup>8</sup> The former West Germany (WGE) and reunited Germany (GE+) are shown separately so that their different behavior can be compared, and because no data on the regions of the former East Germany are available before 1991. While convergence of GDPpc is evident for the entire Germany, the opposite seems to happen among the regions of the former West Germany (the standard deviation of GDPpc increases slightly after 1991).

Overall, it seems that for most of the EU countries there is no evidence of  $\sigma$  convergence among their regions in the time period considered, which may help explain the lack of convergence for the entire EU at the regional level. This result contrasts with the findings of Barro and Sala-i-Martin (1991, 1995) and Sala-i-Martin (1996a,b) that found evidence of  $\sigma$  convergence among regions within some European countries. This difference of results may be due to the fact that I work with regions at a more disaggregated level and that my regional sample starts in 1977 (instead of 1950). In fact, the above-mentioned studies do not show much evidence of  $\sigma$  convergence within EU countries after 1977.

## 5 TRANSITIONAL DYNAMICS

Quah (1996b) argues that the concepts of  $\beta$  and  $\sigma$  convergence may not capture the most important information regarding convergence, which is how one part of the distribution is behaving relative to another. First, cross-section and panel regressions can represent only average behavior, not the behavior of an entire distribution. Second, standard deviations do not capture the transition dynamics, especially information on the persistence of rankings and switching of ranks. Thus, besides checking whether poorer countries are growing faster than rich ones, or if income dispersion is decreasing, it is also important (or even more important) to find out if country and regional rankings are persistent, and to analyze the evolution of the distribution of relative GDP per capita.

### 5.1 *Country and regional rankings and transition matrices*

Table 4 shows the evolution of country rankings from 1960 to 1997. Although Luxembourg is always the richest country, there is some trading of places going on, especially in the middle of the scale. Comparing the first year with the last, “ch(60-97)”, the major



“losers” are Sweden and the United Kingdom, and the major “winners” are Belgium, Austria, and Ireland. Ireland’s and Sweden’s performances from 1990 to 1997 are the most astonishing, with the former jumping five places in the scale and the latter losing seven places. Spearman correlation coefficients for the five years shown against 1960 are reported in the last column. Correlations are usually high, and the null hypothesis of no correlation between the rankings was always rejected. Thus, although there is some movement along the scale, country rankings in the EU show some degree of persistence.

**Table 4: Evolution of country rankings (1960-97)**

|           | BE | DK | GE | GR  | SP | FR | IRL | IT | LU | NL | AT | PO  | FIN | SW | UK | S. Corr |
|-----------|----|----|----|-----|----|----|-----|----|----|----|----|-----|-----|----|----|---------|
| 1960      | 8  | 5  | 4  | 14  | 13 | 7  | 12  | 11 | 1  | 6  | 9  | 15  | 10  | 2  | 3  | 1***    |
| 1970      | 8  | 4  | 3  | 14  | 12 | 5  | 13  | 10 | 1  | 6  | 9  | 15  | 11  | 2  | 7  | .95***  |
| 1980      | 5  | 8  | 2  | 14  | 12 | 3  | 13  | 9  | 1  | 7  | 6  | 15  | 11  | 4  | 10 | .81***  |
| 1990      | 7  | 6  | 2  | 15  | 12 | 3  | 13  | 8  | 1  | 10 | 5  | 14  | 9   | 4  | 11 | .76***  |
| 1997      | 3  | 2  | 5  | 15  | 13 | 6  | 8   | 9  | 1  | 7  | 4  | 14  | 12  | 11 | 10 | .61**   |
| average   | 7  | 4  | 3  | 14  | 12 | 5  | 13  | 9  | 1  | 7  | 7  | 15  | 11  | 4  | 8  |         |
| stdev     | 2  | 1  | 1  | 0.6 | 0  | 2  | 1   | 1  | 0  | 2  | 2  | 0.4 | 1   | 3  | 2  |         |
| ch(60-97) | 5  | 3  | -1 | -1  | 0  | 1  | 4   | 2  | 0  | -1 | 5  | 1   | -2  | -9 | -7 |         |

Source: Author’s calculations using European Commission (1997a).

Notes: - countries were ranked in descending order (richest = 1, poorest = 15);

- “S. Corr” is the Spearman Correlation Coefficient of the rankings of the respective year with those of 1960. The null hypothesis of zero correlation is rejected at a significance level of: \*\*\*=1%, and \*\*=5%;

- averages and standard deviations are based on yearly rankings of countries and not just on the 5 years reported in the upper part of the table.

**Table 5: Spearman correlation coefficients for EU regions**

|      | NUTS I Regions |      |      |      | NUTS II Regions |      |      |      |
|------|----------------|------|------|------|-----------------|------|------|------|
|      | 1977           | 1981 | 1988 | 1995 | 1977            | 1981 | 1988 | 1995 |
| 1977 | 1              |      |      |      | 1               |      |      |      |
| 1981 | .96            | 1    |      |      | .95             | 1    |      |      |
| 1988 | .89            | .94  | 1    |      | .89             | .93  | 1    |      |
| 1995 | .81            | .83  | .84  | 1    | .83             | .89  | .93  | 1    |

Source: Author’s calculations using Eurostat (1998), *REGIO Regional Database*.

Note: In all cases, the null hypothesis of zero correlation is rejected at the 1% significance level.

Table 5 shows matrices of Spearman correlation coefficients for EU NUTS I and NUTS II regions. Again, coefficients are usually very high (the smallest is .81), and the null hypothesis of no correlation is always rejected at the 1% significance level. Thus, it seems that the degree of persistence of regional rankings is very high.

Another way of evaluating the persistence of regional rankings is to divide the regions into quintiles or income categories in the beginning of a period, and find out how many stayed there or moved to another quintile or category after some time. Table 6 shows the transition matrix of 165 NUTS II regions between 1981 and 1995<sup>9</sup>. In the top panel, regions were sorted in ascending order according to their relative GDPpc of 1981 and grouped into quintiles. Then, the same was done for 1995, and the two results were compared in order to find out how many regions stayed in the same quintile and how many changed to a superior or inferior quintile. For example, the first row indicates that 33 regions were in the first quintile in 1981. Of these, 29 remained there, 3 moved to the second quintile, and 1 moved to the third quintile. In percentages, this means that 88% of the regions starting in the first quintile stayed there, 9% moved to the second quintile, and 3% moved to the third quintile.

The diagonal cells indicate the number or the percentage of regions that stayed in the same quintile after 14 years. It seems that there is some persistence in the extremes (1st and 5th quintiles), with percentages above 75%, and much more movement in the middle (the percentage of regions that started and stayed in the 3rd and 4th quintiles is only 36% and 42%, respectively). One should note that this persistence may happen because regions in the second, third, and fourth quintiles have very similar GDPpc, meaning that a small variation in these would make them jump to a different quintile. For those in the first and fifth quintiles, a much

---

<sup>9</sup> 1981 was chosen as the starting date because for previous years there is generally a considerably smaller number of observations. Transition matrices were not computed for NUTS I regions because of the relatively reduced number of observations (a maximum of 76).

bigger variation of GDPpc may be required to jump to a different quintile. Furthermore, the regions in the extremes can only move in one direction.

**Table 6: Transition matrix for NUTS II regions (1981-95)**

|        |          | Number of Regions |    |    |    |    | Percentages |      |      |      |      |
|--------|----------|-------------------|----|----|----|----|-------------|------|------|------|------|
| Number | Quintile | 1                 | 2  | 3  | 4  | 5  | 1           | 2    | 3    | 4    | 5    |
| 33     | 1        | 29                | 3  | 1  |    |    | 0.88        | 0.09 | 0.03 |      |      |
| 33     | 2        | 4                 | 20 | 8  | 1  |    | 0.12        | 0.61 | 0.24 | 0.03 |      |
| 33     | 3        |                   | 8  | 12 | 12 | 1  |             | 0.24 | 0.36 | 0.36 | 0.03 |
| 33     | 4        |                   | 2  | 10 | 14 | 7  |             | 0.06 | 0.30 | 0.42 | 0.21 |
| 33     | 5        |                   |    | 2  | 6  | 25 |             |      | 0.06 | 0.18 | 0.76 |

| Number | Percent     | ≤60 | 80 | 100 | 120 | >120 | ≤60  | 80   | 100  | 120  | >120 |
|--------|-------------|-----|----|-----|-----|------|------|------|------|------|------|
| 17     | ≤60         | 8   | 9  |     |     |      | 0.47 | 0.53 |      |      |      |
| 27     | >60 & ≤80   | 3   | 17 | 7   |     |      | 0.11 | 0.63 | 0.26 |      |      |
| 65     | >80 & ≤100  |     | 5  | 45  | 15  |      |      | 0.08 | 0.69 | 0.23 |      |
| 41     | >100 & ≤120 |     |    | 10  | 24  | 7    |      |      | 0.24 | 0.59 | 0.17 |
| 15     | >120        |     |    |     |     | 15   |      |      |      |      | 1.00 |
| 165    | Total95     | 9   | 34 | 62  | 34  | 26   |      |      |      |      |      |

Source: Author's calculations using Eurostat (1998), *REGIO Regional Database*.

This problem is accounted for in the lower panel of Table 6 where regions were grouped into income categories (as a percentage of the EU average) instead of quintiles. Now, the number of regions in each category varies widely, ranging from 17 below 60% of the average, to 65 between 80% and 100%. There is now an even greater persistence in the richest income group, but the poorest income group (“<60”) exhibits the lowest persistence of all: 47% of the regions stayed there, contrasting with the upper panel where 88% of the regions starting in the lowest quintile stayed there. Thus, it seems that some of the poorest regions are getting closer to the average GDP per capita in the EU.

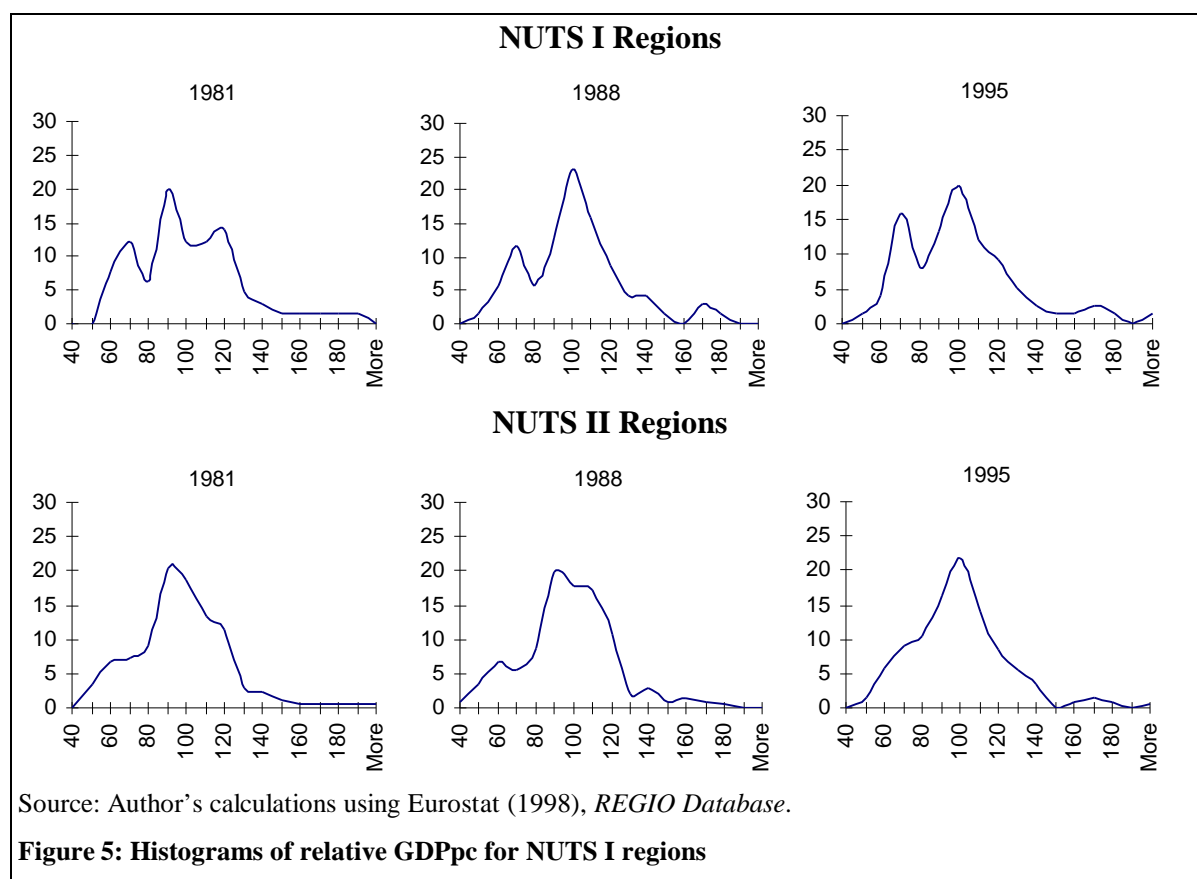
In short, there is a considerable degree of persistence in country and regional rankings. Spearman correlation coefficients never reject the null hypothesis of no correlation, and they are always very high for EU regions. Although there is some trading of places going on among countries, especially after 1980, transition matrices for NUTS II regions show a high degree of

persistence for the first and fifth quintiles and for the highest income category. The poorest regions are getting closer to the EU average (the number of regions in the poorest income category decreased) but they do not seem to be going much higher in the ranking.

## 5.2 *Histograms and contour plots*

It is also possible to have an idea of the transitional dynamics by analyzing the evolution of the distribution of relative GDPpc over time. Figure 5 is a sequence of histograms for GDPpc as a percentage of the EU average for European regions in three different years. Each histogram has GDP per capita as a percentage of the EU average in the horizontal axis and the percentage of regions in the vertical axis. For example, in 1981 around 10% of the NUTS I regions had a GDPpc between 60 and 70 per cent of the EU average and 20% of the regions were between 80 and 90 per cent of that average. It should also be noted that if regions were converging towards the EU average, there should be an increasing concentration in the center and a decreasing concentration in the tails.

For NUTS I regions, the major peak tends to remain around the EU average, but there is no evidence of a decreasing concentration in the tails. The right tail has been increasing, especially for values up to 140 per cent of the EU average, and a second peak is becoming more evident in the left side (around 70). Furthermore, the percentage at the major peak has not changed much since 1981. Also, a third (but smaller) peak may be emerging around 170% of the EU average. Thus, just by looking at these three snapshots of the distribution of relative GDP per capita at the NUTS I level, it seems that there is some clustering outside the center, or a “twin peaks” evolution like the one Quah (1997) suggests there is for his sample of 105 countries.



In the histograms of NUTS II regions the second peak, around 60% of the EU average, is considerably smaller than for NUTS I regions and may be disappearing. The first peak has generally a higher percentage, and a possible third peak is rather small and is not becoming more pronounced over time. Thus, it seems that for a greater level of detail there is not so much evidence in favor of a “twin peaks” evolution.

Figure 5 gives an idea of how the distribution of regional GDPpc looks like in three different points in time. It would also be useful to represent the evolution of that distribution for the entire time-period considered in just one picture. That is done for NUTS II regions in Figure 6, which presents two perspectives of the histograms of GDPpc as a percentage of the EU average from 1977 to 1995. The distribution of NUTS II regions shows that the highest percentages tend to stay around the EU average, as peaks stay in line with each other forming a mountainous ridge. The percentage at the major peak is decreasing and a smaller second

peak seems to appear in the later years (after the Maastricht Treaty) around 60% of the EU average.

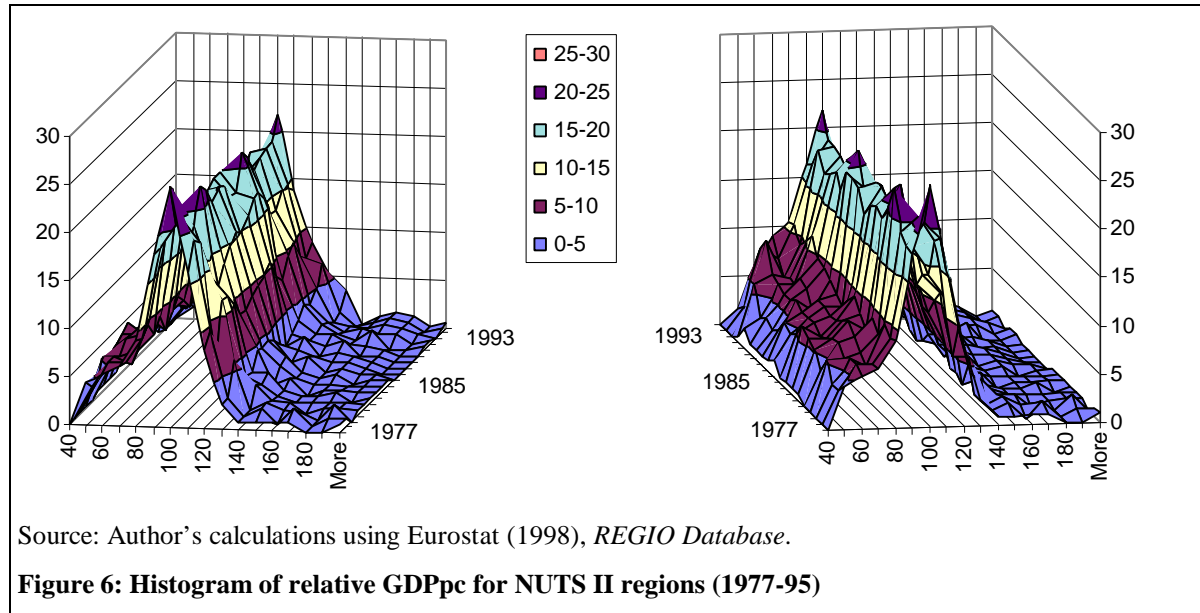
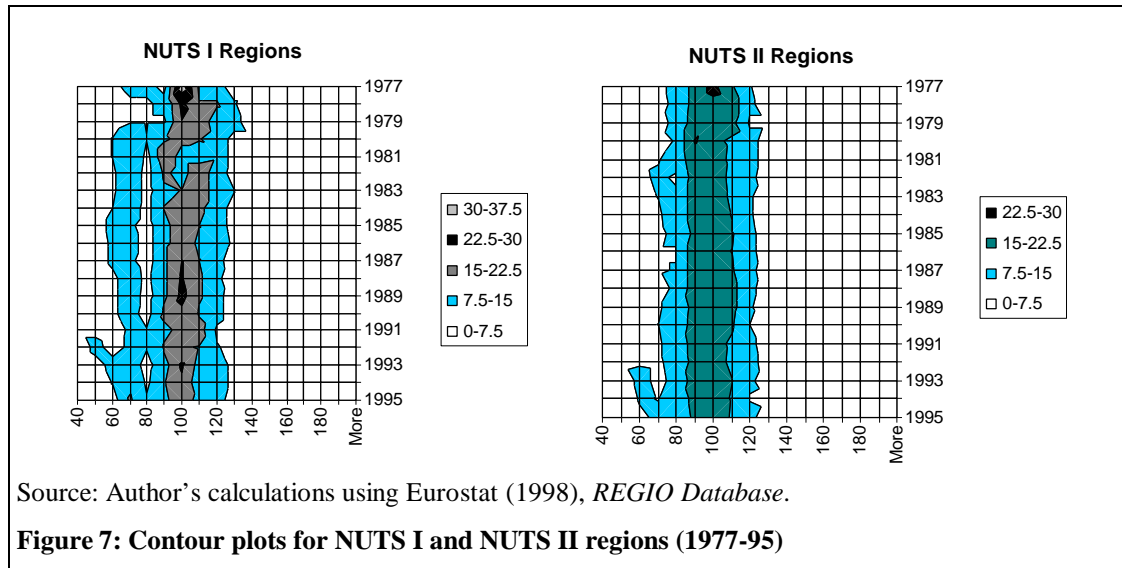


Figure 7 shows contour plots of the histograms of relative GDPpc for NUTS I and NUTS II regions. Since they are just a different way of presenting the information contained in the last figure, the pattern described above remains. Percentages above 15% tend to be between 90 and 110 per cent of EU average GDPpc, they are lower than 7.5% for values above 130, and there is more evidence of a second peak for NUTS I than for NUTS II regions. It is also worth mentioning that this second peak is more pronounced after the Maastricht Treaty than before (mainly for NUTS II regions for which evidence of a second peak appears only after 1992). Although it is hard to know if the distribution for NUTS II regions is also tending towards twin peakedness, because the small second peak may just fade away as those regions get richer, it is possible to conclude that there has not been a general

tendency of clustering towards the center. In fact, the distribution of relative GDP per capita of NUTS I and NUTS II regions has not changed significantly over the years.<sup>10</sup>



In short, the evolution of the distribution of relative GDP per capita among EU regions does not provide much evidence in favor of convergence. There is no pattern of increased concentration at the center (around the average) in either of the two distributions, there is some evidence of “twin-peakedness” for NUTS I regions, and a small second peak seemed to be emerging in the distribution of relative GDPpc of NUTS II regions after 1992. This is consistent with the results of the previous section concerning the lack of  $\sigma$  convergence at the regional level.

## 6 CONCLUSIONS

This essay deals with convergence of GDP per capita in the EU. Convergence generally happens if GDPpc grows faster in poorer countries or regions than in rich ones ( $\beta$

<sup>10</sup> For a more sophisticated analysis of transition dynamics see: Quah (1996a,b,c,d and 1997).

absolute convergence), or if the dispersion of GDPpc across countries or regions is decreasing ( $\sigma$  convergence). Low persistence of country or regional rankings and an evolution of the distribution of GDPpc towards single-peakedness with concentration at the average are also consistent with convergence.

There is evidence of  $\beta$  absolute convergence among countries since 1960, with an estimated annual rate of convergence of 2.45%. This implies that the average disparity of GDPpc would be cut in half within 28 years. Evidence of convergence for countries is found only for the sub-period 1960-72, meaning that most of the convergence referred above took place before 1973. These findings are consistent with those of Ben-David (1993) that found convergence among EU countries to have been faster before the 1970s than after. According to him, this was due to the greater extent of trade liberalization that took place during the 1950s and 1960s.

The estimated speed of convergence among regions seems to depend heavily on those of the former East Germany. When they are excluded from the sample, rates of convergence get much smaller, resulting in half-lives comparable to or even higher than those for countries. Convergence also seems to have been slower after Maastricht than before in the estimations where those regions are excluded.

While there is evidence of  $\sigma$  convergence for countries, with standard deviations decreasing at least until the late 1970s, that happens for regions only after 1991. Again, this is due to the regions of the former German Democratic Republic. Evidence of convergence for regions within the same country was not found for most of the EU countries, which may help explain the different results at the country and regional levels. This result contrasts with the findings of Barro and Sala-i-Martin (1991, 1995) and Sala-i-Martin (1996a,b) that found evidence of  $\sigma$  convergence among regions within some European countries. Part of the



contrasting evidence can be attributed to the fact that I work with a smaller time period (starting in 1977 instead of 1950). Most of the evidence of  $\sigma$  convergence that those studies find took place before the mid-1970s. After that, the dispersion of GDPpc is quite stable for most countries, which is consistent with my results. The remaining differences between their results and mine may be due to the fact that I work with a larger sample: a larger number of countries; and generally, more regions per country.

Country and regional rankings show a considerable degree of persistence, and the regional distribution of GDPpc relative to the EU average looks very stable across time, with no clear tendency towards increased concentration at the center. On the contrary, a second peak is found for NUTS I regions and it appears in the last two or three years for NUTS II regions. In short, there is some evidence of convergence for countries, although rankings are somewhat persistent, but not for regions.

Finally, it is arguable that the efforts towards inflation reduction and fiscal rectitude may help explain why convergence of GDP per capita relative to the EU average has been generally slower after the Treaty of Maastricht than before. As some of the poorest countries of the EU were also the ones farther away from fulfilling the convergence criteria, the restrictive monetary and fiscal policies that they had to implement in order to reduce inflation, budget deficits, and public debt slowed their economic growth and, consequently, the convergence of GDP per capita in the EU. Although the reduction of inflation, fiscal deficits, and public debt may be beneficial for economic growth in the long run, that reduction could probably have been made with smaller economic costs inside a monetary union. That is, economic growth in Europe could have been faster in the last five years if the convergence criteria had been dropped and EMU started earlier.

## 7 REFERENCES

- Barro, Robert J. (1991), "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, 106, May, 407-443.
- Barro, Robert J. and Xavier Sala-i-Martin (1991) "Convergence Across States and Regions," *Brookings Papers on Economic Activity*, 1:1991, 107-182.
- Barro, Robert J. and Xavier Sala-i-Martin (1995), *Economic Growth*, McGraw-Hill, New York, NY.
- Barros, Pedro Pita and Nuno Garoupa (1996), "Portugal-European Union Convergence: Some Evidence," *European Journal of Political Economy*, 12, 545-553.
- Baumol, William J. (1986), "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show," *American Economic Review*, 76(5), 1072-1085.
- Ben-David, Dan (1993), "Equalizing Exchange: Trade Liberalization and Income Convergence," *Quarterly Journal of Economics*, August, 653-679.
- Ben-David, Dan (1996), "Trade and Convergence among Countries," *Journal of International Economics*, 40(3/4), 279-298.
- Caselli, Francesco, Gerardo Esquivel, and Fernando Lefort (1996), "Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics," *Journal of Economic Growth*, 1(3), 363-389.
- Cohen, Daniel (1996), "Tests of the "Convergence Hypothesis": Some Further Results," *Journal of Economic Growth*, 1(3), 351-361.
- De Long, Bradford (1988), "Productivity Growth, Convergence, and Welfare: Comment," *American Economic Review*, 78(5), 1138-1154.
- European Commission (1996a), "Economic Evaluation of the Internal Market," *European Economy - Reports and Studies*, No 4, OOPEC, Luxembourg.
- European Commission (1996b), "The Economic and Financial Situation in Ireland," *European Economy - Reports and Studies*, No 1, OOPEC, Luxembourg.
- European Commission (1997a), "Annual Economic Report for 1997," *European Economy*, No 63, OOPEC, Luxembourg.
- European Commission (1997b), "The Economic and Financial Situation in Portugal," *European Economy - Reports and Studies*, No 1, OOPEC, Luxembourg.
- European Commission (1997c), *European Economy - Supplement A: Economic Trends*, No 10, October, OOPEC, Luxembourg.

- Eurostat (1998), *REGIO Regional Database*, CD-ROM Version of 8/1998.
- Galor, Oded (1996), "Convergence? Inferences from Theoretical Models," *The Economic Journal*, 106(July), 1056-1069.
- Greene, William H. (1993), *Econometric Analysis*, second edition, New York, NY: McMillan Publishing Company.
- Islam, Nazrul (1995), "Growth Empirics: A Panel Data Approach," *Quarterly Journal of Economics*, 110, November, 1127-1170.
- Mankiw, N. Gregory, David Romer, and David N. Weil (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, 107, May, 407-437.
- Quah, Danny T. (1996a), "Convergence Empirics Across Economies with (Some) Capital Mobility," *Journal of Economic Growth*, 1(1), 95-124.
- Quah, Danny T. (1996b), "Empirics for Economic Growth and Convergence," *European Economic Review*, 40, 1353-1375.
- Quah, Danny T. (1996c), "Regional Convergence Clusters across Europe," *European Economic Review*, 40, 951-958.
- Quah, Danny T. (1996d), "Twin Peaks: Growth and Convergence in Models of Distribution Dynamics," *The Economic Journal*, 106(July), 1045-1055.
- Quah, Danny T. (1997), "Empirics for Growth and Distribution: Stratification, Polarization, and Convergence Clubs," *Journal of Economic Growth*, 2(1), 95-124.
- Sala-i-Martin, Xavier (1996a), "Regional Cohesion: Evidence and Theories of Regional Growth and Convergence," *European Economic Review*, 40, 1325-1352.
- Sala-i-Martin, Xavier (1996b), "The Classical Approach to Convergence Analysis," *The Economic Journal*, 106(July), 1019-1036.
- Veiga, Francisco José (1998), *Inflation Stabilization*, Ph.D. Dissertation, University of South Carolina, Columbia, SC.